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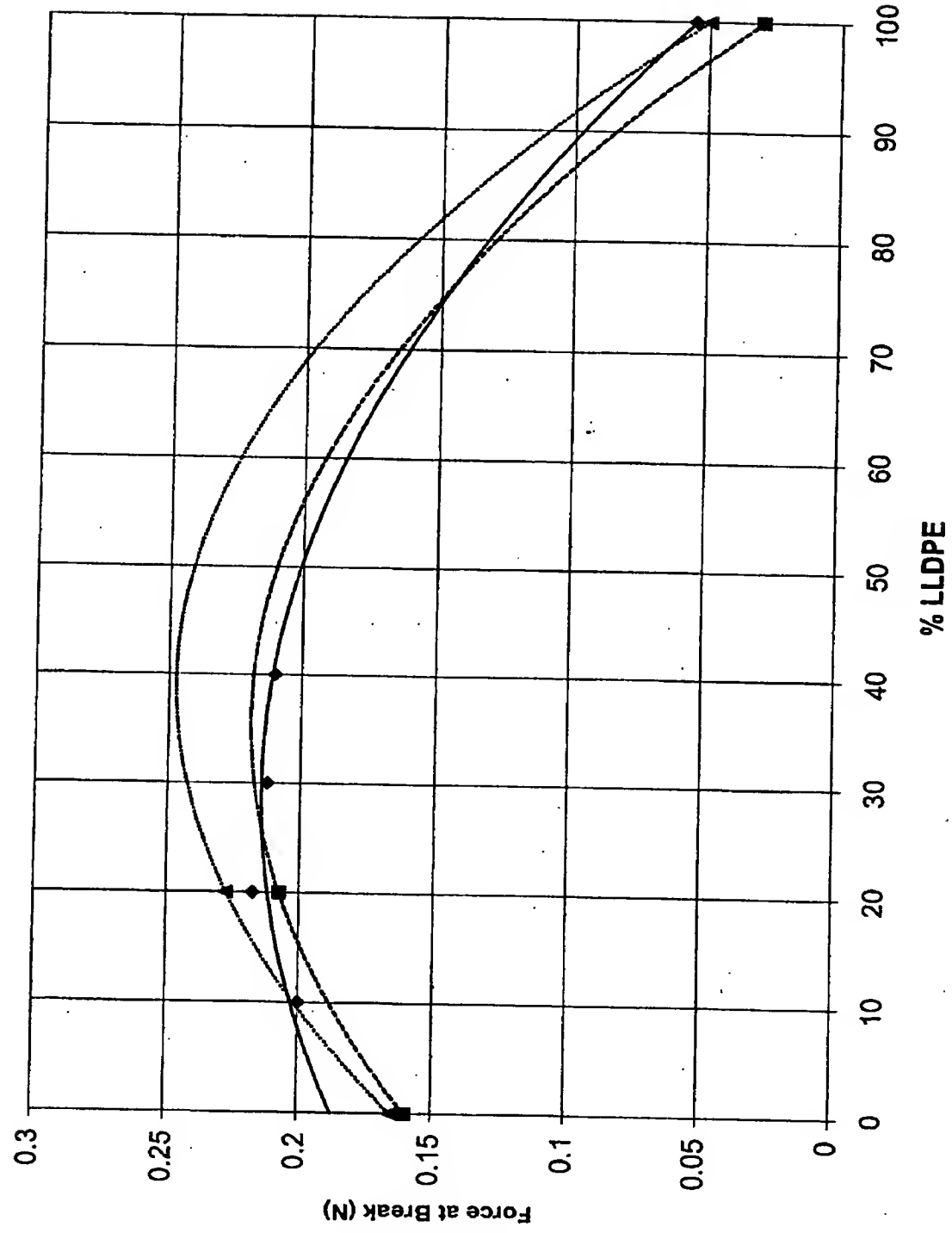
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(54) Abstract Title: **Polyolefin foam**

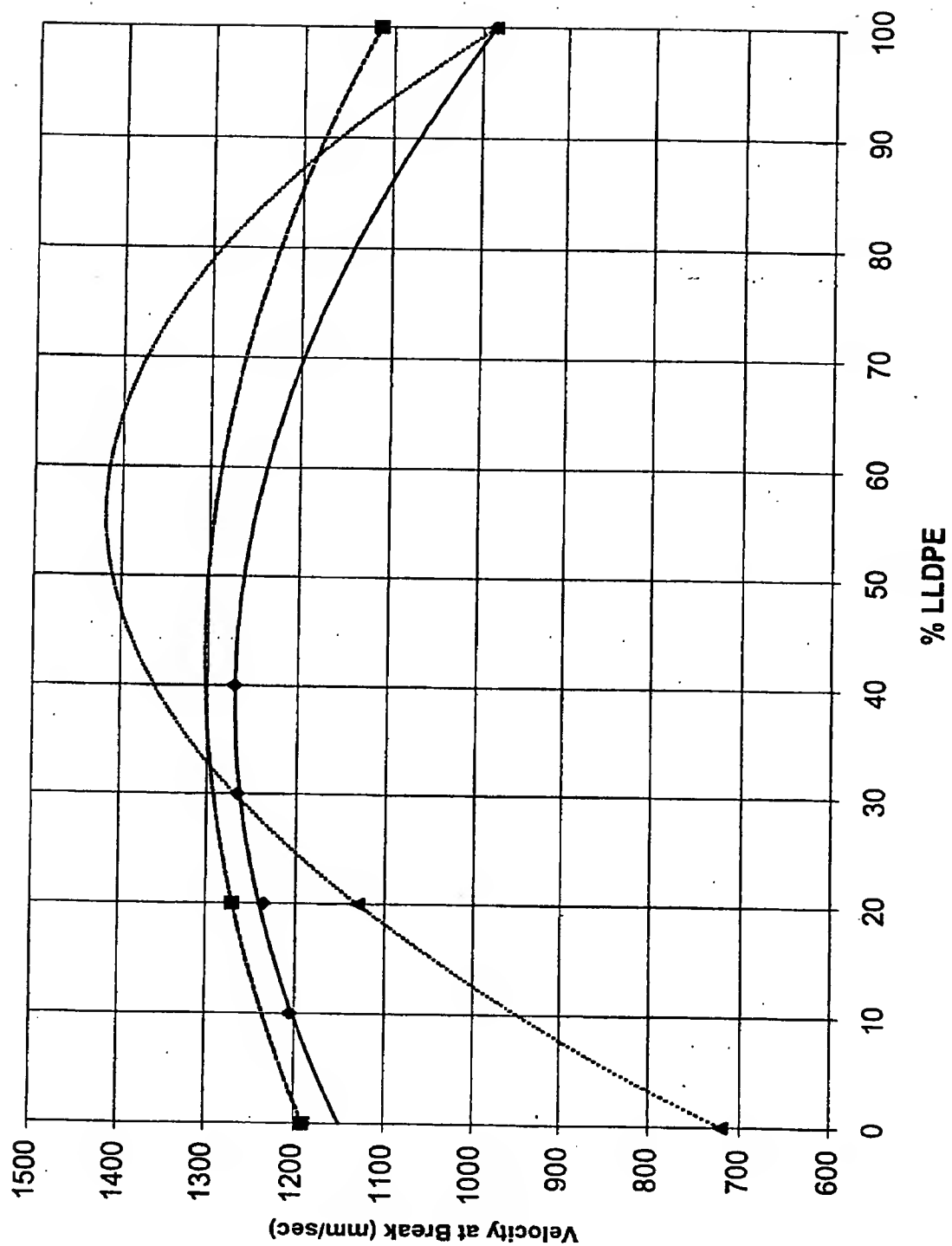
(57) A polyolefin foam comprising a plastics component and a blowing agent, the plastics component consisting primarily only of a first constituent and a second constituent; characterised in that the first constituent is a Ziegler-Natta catalysed linear low density polyolefin and the second constituent is a low density polyolefin. Also disclosed is a method for manufacturing the polyolefin foam.

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Force at Break versus % LLDPE

FIG 1

Velocity at Break versus % LLDPE

FIG 2

# Force versus Velocity

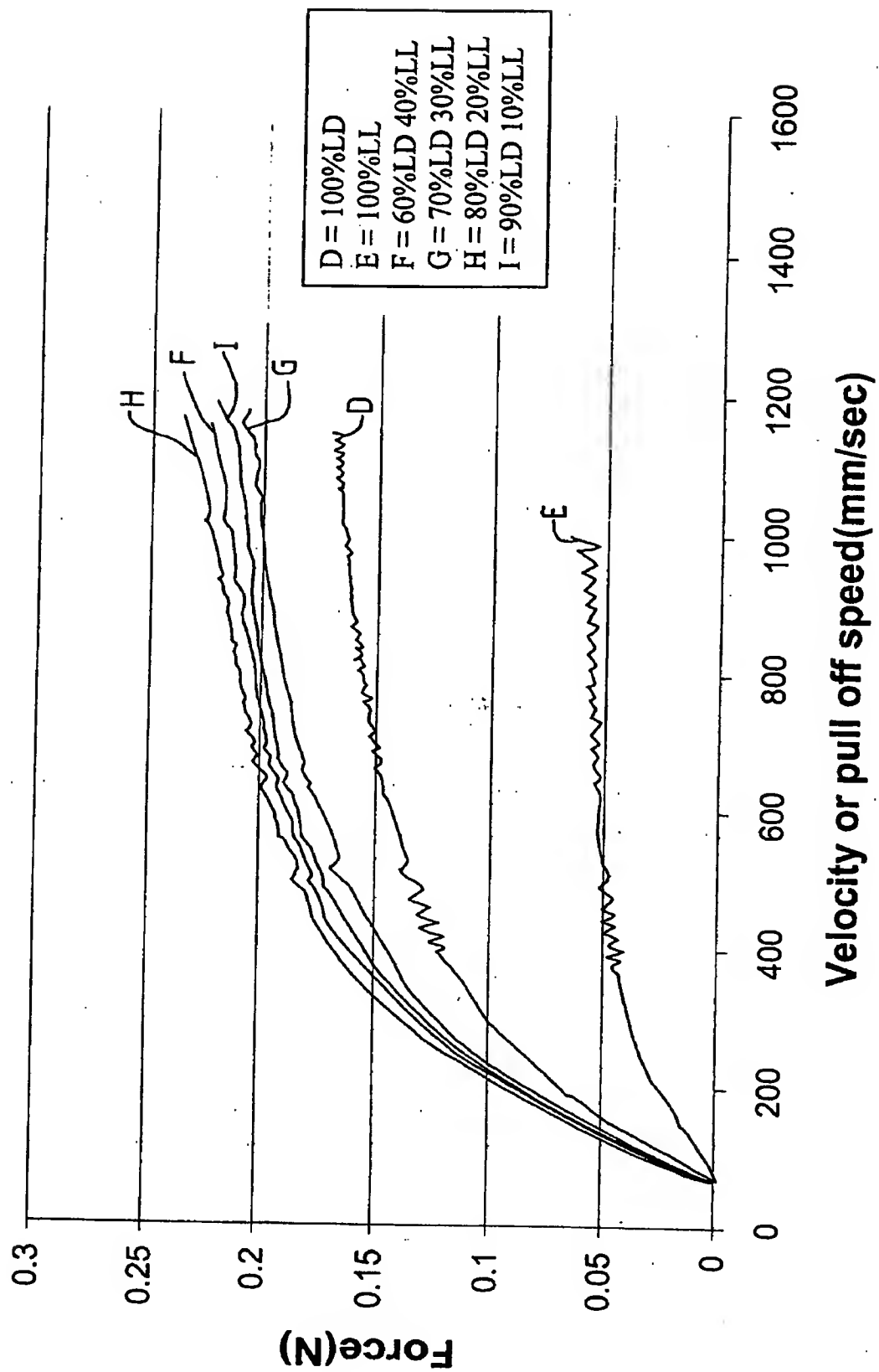


FIG 3

Force and Drawability versus %LLDPE

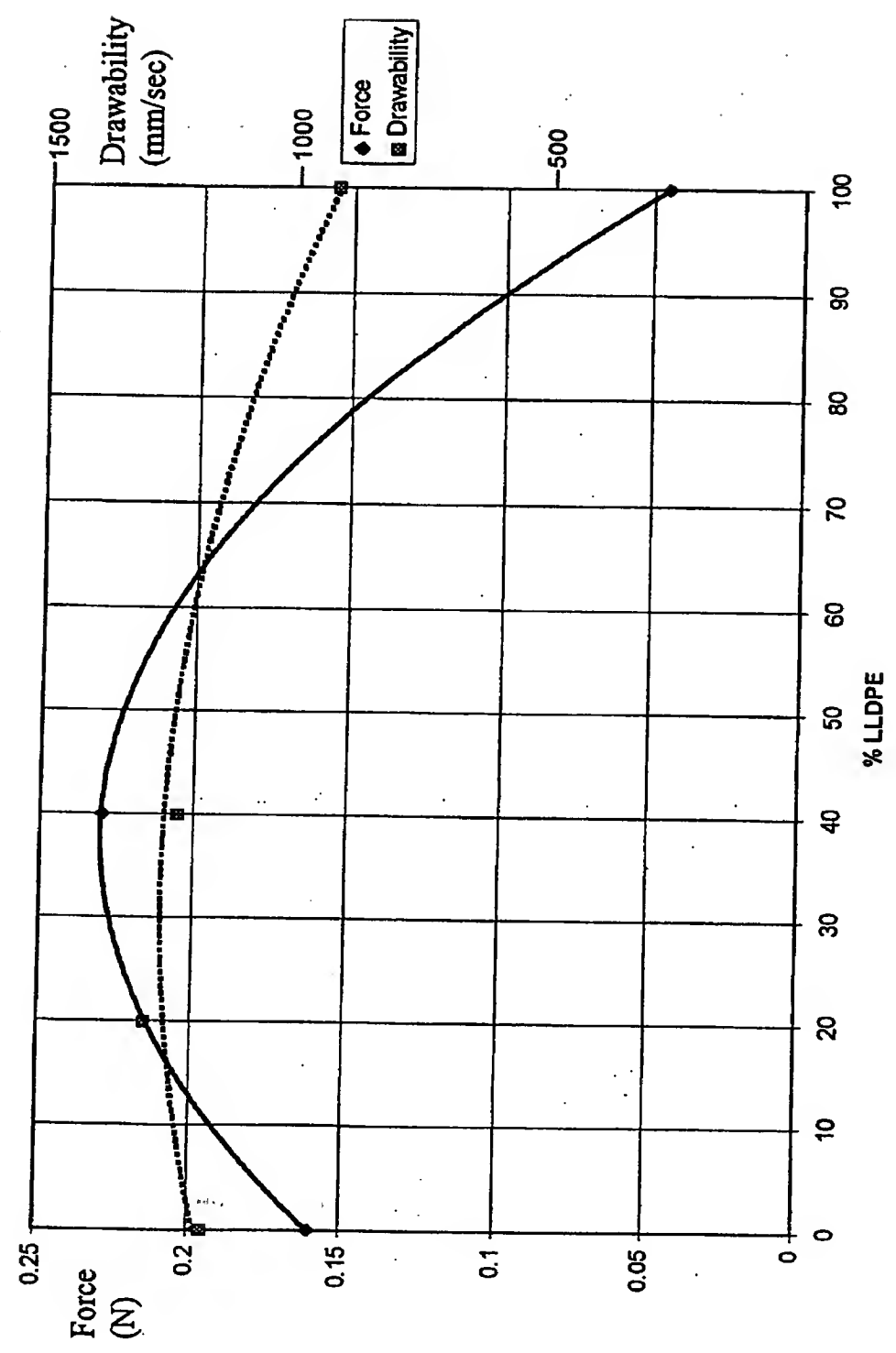


FIG 4

Title: Improvements Relating To Foam Materials

Description of Invention

5        This invention is concerned with improvements relating to foam materials, particularly, but not exclusively, low density polyolefin foam materials, of the kind which may be utilised as packaging and/or cushioning materials, and is particularly concerned with the manufacture of a closed cell plastics foam.

10        A closed cell plastics foam is hereinafter defined as one in which the majority of the cells are closed. Typically, a closed cell foam of a reasonable quality will have at least 70% closed cells, and a closed cell foam of a good quality will have at least 85% closed cells, although this may be less in thin sheets, for example 1 mm or less.

15        A conventional starting material used in the manufacture of low density polyolefin foam is a polyolefin resin such as a highly branched low density polyethylene (LDPE), typically manufactured by the high pressure radical polymerisation process, such as tubular autoclave, etc. In this process the monomers are mixed thoroughly under high pressure and at a high heat which  
20 induces polymerisation, and forms a polyethylene resin.

To produce a foam, this polyethylene resin, typically in pelletised form, is then plasticised in a screw extruder, and mixed with a blowing agent. When the material is extruded, for example into sheet form, the blowing agent expands, producing a large number of small bubbles.

25        Where the polyethylene foam is used as a packaging material, whilst some physical strength characteristics are important, cost is very important, and over many years much effort has been put into reducing cost.

To date, a majority of the effect in reducing the cost has been directed towards lowering the density of the foam, and, by conventional techniques, it is possible to produce a material having a density as low as 15 to 20 kg/m<sup>3</sup>.

Alternative materials have been considered in an attempt to reduce the cost further. In particular a number of attempts have been made to use a linear low density polyolefin such as a linear low density polyethylene (LLDPE). LLDPE is typically manufactured at a lower pressure and a lower heat, using catalysts. Hence it is approximately 10% less expensive than LDPE.

However, conventional Ziegler-Natta LLDPE, hereinafter defined as LLDPE manufactured without using a metallocene (or a similar substance) as a catalyst, contains predominantly linear polymer chains with irregular short chain branching and no substantial long-chain branching, having a narrow molecular weight distribution (MWD) which results in the material having poor foaming characteristics, specifically having a lower melt strength.

LLDPE may be produced by the use of different catalyst systems, eg. a metallocene catalyst, which can lead to the production of polymers having substantial long-chain side branching, resulting in a material having a broad MWD, and having a higher melt strength. This method consequently has a higher cost. Such LLDPE may be blended with LDPE to produce a material which may be foamed to the required low density. However, metallocene catalysation is an expensive process, and the cost of such modified LLDPE results in a material which is in fact more expensive than LDPE itself.

Alternatively, it is possible to add cross-linking agents such as organic peroxides to the LLDPE/LDPE mix, which again increase the extent of long-chain branching and the melt strength of the mix. However, these additional compounds are, in themselves, expensive.

Attempts have been made to produce a foam from a blend of small quantities of conventional Ziegler-Natta LLDPE with LDPE, but it has been found that the melt strength of the blend is increased and so difficulty is

encountered in achieving a low a density as is obtained using 100% LDPE, again resulting in a higher cost outweighing the savings resulting from the use of LLDPE.

Surprisingly, it has been found by the present applicants that, when  
5 LLDPE is blended in higher amounts with LDPE, a material is produced which may be foamed to a low density foam product, with no increase in density compared with that which is obtained using 100% LDPE. Additionally, it has been found by the present applicants that, when the foaming process is slightly modified, it is possible to produce a material which has good foaming  
10 characteristics and a low density, even when blending small amounts of LLDPE with LDPE.

In this manner, small but significant savings may be obtained in the manufacture of polyethylene foam.

Additionally, by the use of LLDPE, an increase in the toughness and  
15 elasticity of the foam is obtained, providing a higher degree of protection during, for example, transportation of the article.

According to a first aspect of this invention there is provided a polyolefin foam comprising a plastics components and a blowing agent, the plastics component consisting primarily only of a first constituent and a second  
20 constituent; characterised in that the first constituent is a Ziegler-Natta catalysed linear low density polyolefin and the second constituent is a low density polyolefin. Preferably the second constituent is a low density polyethylene.

According to a second aspect of this invention there is provided a  
25 polyolefin foam comprising a plastics component and a blowing agent, the plastics component consisting primarily only of a first constituent and a second constituent, characterised in that the first constituent is a Ziegler-Natta catalysed linear low density polyethylene and the second constituent is a



polypropylene. Preferably the second constituent is a high melt strength polypropylene.

The plastics component consists primarily only of the mixtures specified above. This means that although other substances may be present in trace  
5 amounts, such trace substances are not thought to effect the foamability of the plastics component.

Additionally, nucleating agents and ageing modifiers may be incorporated in conventional manner.

The plastics component may consist primarily of from 1% to 85% of the  
10 first constituent, and from 99% to 15% of the second constituent.

Alternatively the plastics component may consist primarily of from 5% to 10% of the first constituent, and from 95% to 90% of the second constituent.

Alternatively the plastics component may consist primarily of from 10% to 15% of the first constituent, and from 90% to 85% of the second constituent.

15 Alternatively the plastics component may consist primarily of from 15% to 20% of the first constituent, and from 85% to 80% of the second constituent.

Alternatively the plastics component may consist primarily of from 20% to 25% of the first constituent, and from 80% to 75% of the second constituent.

20 Alternatively the plastics component may consist primarily of from 25% to 30% of the first constituent, and from 75% to 70% of the second constituent.

Alternatively the plastics component may consist primarily of from 30% to 35% of the first constituent, and from 70% to 65% of the second constituent.

Alternatively the plastics component may consist primarily of from 35% to 40% of the first constituent, and from 65% to 60% of the second constituent.

25 The foam may have a density of less than  $90 \text{ kg/m}^3$ , conveniently less than  $50 \text{ kg/m}^3$ , preferably having a density of less than  $30 \text{ kg/m}^3$ , and most preferably having a density of less than  $20 \text{ kg/m}^3$ .

Preferably the second constituent consists primarily of a polyethylene. Alternatively, the second constituent may consist primarily of a polypropylene, preferably a high melt strength polypropylene.

According to a third aspect of this invention there is provided a method  
5 of manufacturing a polyolefin foam, involving mixing as resin constituents primarily only a first constituent and a second constituent in an extruder, adding a blowing agent to the resultant mixture, and extruding the resultant mix into foam form; characterised in that the first constituent is a Ziegler-Natta catalysed linear low density polyolefin and the second constituent is a low density  
10 polyolefin. Preferably the second constituent is a low density polyethylene.

According to a fourth aspect of this invention there is provided a method of manufacturing a polyolefin foam involving mixing as resin constituents primarily only a first constituent and a second constituent in an extruder, adding a blowing agent to the resultant mixture, and extruding the resultant mix into  
15 foam form; characterised in that the first constituent is a linear low density polyethylene and the second constituent is a polypropylene. Preferably the second constituent is a high melt strength polypropylene.

The first constituent may be present in an amount between 1% and 85% by weight of the total polyolefin content.

20 Alternatively the first constituent may be present in an amount between 5% and 10% by weight of the total polyolefin content.

Alternatively the first constituent may be present in an amount between 10% and 15% by weight of the total polyolefin content.

Alternatively the first constituent may be present in an amount between  
25 15% and 20% by weight of the total polyolefin content.

Alternatively the first constituent may be present in an amount between 20% and 25% by weight of the total polyolefin content.

Alternatively the first constituent is present in an amount between 25% and 30% by weight of the total polyolefin content.

Alternatively the first constituent may be present in an amount between 30% and 35% by weight of the total polyolefin content.

Alternatively the first constituent is present in an amount between 35% and 40% by weight of the total polyolefin content.

5 Preferably the polyolefin foam is a closed cell polyolefin foam.

Using the method set out in the preceding paragraphs, the foam may be extruded to a density of less than  $90 \text{ kg/m}^3$ , conveniently less than  $50 \text{ kg/m}^3$ , preferably being extruded to a density of less than  $30 \text{ kg/m}^3$ , and most preferably being extruded to a density of less than  $20 \text{ kg/m}^3$ .

10 Preferably the second constituent consists primarily of a polyethylene. Alternatively, the second constituent may consist primarily of a polypropylene, preferably a high melt strength polypropylene.

Preferably in carrying out the method the first constituent has a density of between  $900$  and  $950 \text{ kg/m}^3$ , preferably between  $917$  and  $930 \text{ kg/m}^3$ .

15 Preferably also the difference in the crystallisation temperatures of the two resinous constituents of the foam is greater than  $8^\circ\text{C}$ , preferably greater than  $10^\circ\text{C}$ , and preferably about  $12^\circ\text{C}$ .

Preferably the first constituent has a melt flow index (according to ISO 1133) of less than  $10\text{g}/10$  minutes, conveniently less than  $5\text{g}/10$  minutes, 20 preferably less than  $3\text{g}/10$  minutes.

The method may involve the incorporation of nucleating agents and ageing agents.

Preferably the method set out in the preceding paragraphs involves the use of a twin screw extruder. In this manner, an extrudable mixture may be 25 obtained with lower levels of shear force than would be involved by the use of a single screw extruder, allowing effective mixing to be obtained at a lower temperature than would otherwise be the case.

Preferably the method involves controlling the melt temperature of the resin constituents. This may involve ensuring that the melt temperature is compared, preferably matched, to a pre-determined datum, and in this case the datum is preferably derived from the melt temperature resulting when 100% of the second constituent is used.

By the use of the first constituent, an increase in the toughness and elasticity of the foam is obtained, providing a higher degree of protection during, for example, transportation of the article.

Embodiments of this invention will now be described, by way of example only, with reference to the accompanying drawings in which:

FIGURE 1 is a graph which shows schematically the variation in force at break for different percentage blends of LDPE and LLDPE resin, and three different material blends;

FIGURE 2 is a graph which shows schematically the variation in velocity at break for different percentage blends of LDPE and LLDPE resin, and for three different material blends;

FIGURE 3 is a graph which shows schematically the variation in force generated at different pull-off speeds for different percentage blends of LLDPE and LDPE resin; and

FIGURE 4 is a graph which shows schematically how force and drawability vary with different blends of LLDPE and LDPE resin.

Initial experiments were conducted on blends of LDPE and LLDPE resin. Figures 1 to 3 show examples of the results of these initial experiments. The LDPE was produced by the high pressure radical polymerisation process, although, of course, LDPE produced by any other process could be used as an alternative. The LLDPE used was conventional low pressure Ziegler-Natta catalysed LLDPE without the use of metallocenes or similar substances as a catalyst. The particular LLDPE used in these examples was produced with a C<sub>4</sub>

co-monomer, but the results are equally applicable to LLDPE produced from other co-monomers, such as C<sub>6</sub> or C<sub>8</sub> co-monomers.

The blends consist primarily only of LDPE and LLDPE. This means that although other substances may be present in trace amounts, such trace  
5 substances are not thought to affect the characteristics of the blends shown in the graphs.

Referring initially to Figure 1, the force at break of a resin is a measure of the melt strength of the foam. An increase in melt strength means that it is possible to expand the foam to a higher degree, but also means that the foam  
10 tends to be closed cell rather than open cell, and traditionally the problem with adding LLDPE to LDPE is that open celled, and thus ineffective, foams are produced.

However, there is also an upper limit to the melt strength of a foam in that the extra gas which must be used to expand such a foam will cool the  
15 polymer mix more quickly. Thus, the foam needs to be expanded more rapidly without significant resistance.

The data shown in Figure 1 was produced by testing resin which comprises blends of different percentages of LDPE and LLDPE. Trendlines, as shown, have been formed by extrapolation from the data points, using a second  
20 order polynomial.

As can be seen from Figure 1 the force at break for a 0% LLDPE resin (i.e. 100% LDPE resin) is significantly greater, being around six times greater, than the force at break for a 100% LLDPE resin. This is why foams containing large amounts of LLDPE have been previously found to be ineffective, and is  
25 one of the reasons why one would expect the melt strength of a blend of LLDPE and LDPE to be lower than the melt strength of a foam which consists only of LDPE.

The lower melt strength of conventional LLDPE is thought to be due to its lack of long chain branches, which provides an insufficient melt strength to

allow successful foam formation. Thus, previous attempts to improve the melt strength of LLDPE foam have focused on using, for example, metallocene-catalysed LLDPE, which has greater homogeneity and a greater number of long chain branches, or increasing the long branching using cross-linking agents, as outlined earlier.

However, as is also shown in Figure 1, surprisingly, the force at break of a resin which consists of a blend of LLDPE and LDPE can actually be greater than the force at break of either 100% LDPE or 100% LLDPE. This implies that such a blend, although more difficult to foam, could actually produce a less dense foam, since it is possible to retain a larger volume of blowing agent in the foam without the bubbles breaking. Thus, the measures used in previous attempts, may not actually be necessary.

The greater strength, in the film at least, seems to be produced in blends which contain between approximately 1% LLDPE and approximately 85% LLDPE. The greatest strength resin seems to be produced at around 40% LLDPE, depending on the type of LDPE and LLDPE used.

Figure 2 can be seen to follow the same general trend as Figure 1. The velocity at break can be considered to be indicative of the resilience of the resin, and is equivalent to the drawability of the resin. LLDPE, having more linear molecular chains might be thought to have a higher velocity at break. However, this may be offset by the increased force required to break the chain entanglement in the LDPE, compared to the relatively non-entangled LLDPE. Thus, depending on the characteristics of the specific blend used, either the LDPE (as in blends A and B) or the LLDPE (as in blend C) may have a higher velocity at break.

Whichever is higher, one would expect the transition between the two to be relatively linear for different percentages of the two plastics. Surprisingly, however, adding LLDPE to LDPE seems to produce an increase in velocity at break which goes beyond the higher velocity at break of the other component,

implying a synergistic effect. This is particularly noticeable between around 30% of LLDPE and around 70% of LLDPE, in resin form.

Figure 3 shows how the force of the different blends, and the different proportions of the different blends, varies at different velocities or pull-off speeds. As can be seen, the blended versions all require a greater force to achieve any given velocity or pull-off speed than either 100% LDPE or 100% LLDPE. Again, therefore, surprisingly, a combination of LDPE and LLDPE has better properties than either of the two plastics alone. A blend of 80% LDPE and 20% LLDPE seems to have particularly good qualities in these resins.

Figure 4 also shows the synergistic effect for force to break and velocity to break (or drawability) of the resin.

Following these experiments with resin, a further set of experiments were conducted by the applicant with foam. These experiments were conducted using LDPE having a MFR of 2 g/10 mins and a density of 923 kg/m<sup>3</sup>, and conventional Ziegler-Natta LLDPE having MFR of 2.7 g/10 mins and a density of 918 kg/m<sup>3</sup>.

To manufacture the foam, the LLDPE was mixed with the LDPE and extruded using a single screw or a twin screw extruder. The blowing agent used was butane.

The experiments are described in more detail below, but some of the results showed that under the same processing conditions (that is: blowing agent weight, total feed rate and line speed) there was no substantial foam density increase when certain quantities of LLDPE were added to the LDPE.

In fact, surprisingly, at a higher percentage addition of LLDPE, the foam density was reduced to slightly below the same level as for 100% LDPE. In these experiments, the optimum seems to be between about 20% and 25% LLDPE addition. Since LLDPE is currently only 92.5% of the cost of LDPE,

this means a cost saving of 1.5% to 1.9%, and a further benefit is the improved toughness and elasticity of foams having LLDPE added.

Another interesting point may be noted. Materials having a lower melt flow index are generally more difficult to foam to a good quality, since greater  
 5 shear force tends to be generated during the extrusion process. However, using this method it was possible to produce a good quality foam using a LLDPE resin having a low melt flow index (MFI), less than 10g/10 minutes, specifically 2.8g/10 minutes.

No foam collapse was observed at higher LLDPE levels (up to 25%) in  
 10 these runs, and the foam which was produced seemed to be of a similar level of effectiveness to that made using 100% LDPE.

Four different examples of the experiments made will now be described, purely to illustrate the invention. One of these used a single screw extruder and three of these used a twin screw extruder.

15

#### Example 1

Run No.	LDPE Wt %	LLDPE	Foam density kg/m <sup>3</sup>	thickness mm	Foam quality	Melt temp. °C
1	100	0	21.1	1.0	good	96-97
2	75	25	21.4	1.1	good	97
3	65	35	21.2	1.1	good	97

-percentages of LDPE and LLDPE are expressed as weight percentages of the total polyolefine blend

20 -LDPE;mfi:2.0 g/10 min and density of 924 kg/m<sup>3</sup>  
 -LLDPE;mfi:2.8 g/10 min and density of 919 kg/m<sup>3</sup>  
 -blowing agent :isobutane

25 For the first set of these experiments a 120mm single screw extruder was used to manufacture a foam sheet. The first one run was used as a control run, using 100% LDPE.



In the second and third runs, with 25% and 35% LLDPE respectively, the foam quality and density obtained were comparable to that of the foam obtained using 100% LDPE, although it was necessary to adjust the process conditions to control the melt temperature.

5

### Example 2

Run No.	LDPE Wt %	LLDPE Wt %	Foam density kg/m <sup>3</sup>	thickness mm	Foam quality	Melt. Temp. °C
1	100	0	24.2	0.8	good	111
2	90.5	9.5	24.9	0.8	good	112
3	87.1	12.9	24.5	0.8	good	112
4	83.8	16.2	24.3	0.8	good	112
5	80.5	19.5	24.1	0.8	good	112
6	74.8	25.2	24.1	0.8	good	112

- 10 -percentages of LDPE and LLDPE are expressed as weight percentages of the total polyolefine blend  
 -LDPE;mfi:2.0 g/10 min and density of 924 kg/m<sup>3</sup>  
 -LLDPE;mfi:2.8 g/10 min and density of 918 kg/m<sup>3</sup>  
 -blowing agent :iso-/n-butane mixture

- 15 This table shows the results obtained from an experiment with twin screw extruders. The twin screw extruder was 150mm in diameter and was used for producing a 0.8mm sheet of foam from a blend of LDPE and LLDPE. The blowing agent used was an iso/n butane mixture.

- 20 Again, the first run was used as a control run using 100% LDPE. In runs 2 to 6 the amount of LDPE was steadily reduced and the amount of LLDPE was steadily increased. The table shows that foam density actually decreased for 19.5% and 25.2% LLDPE, runs 5 and 6 respectively. The foam quality was good for all blends and it was not necessary to adjust the process conditions to control the melt temperature.

25

**Example 3**

Run No.	LDPE Wt %	LLDPE Wt %	Foam density kg/m <sup>3</sup>	thickness mm	Foam quality	Melt. Temp. °C
1	100	0	22.7	0.8	good	108
2	95	5	22.9	0.8	good	109
3	85	15	22.7	0.8	slight collapse	111-112
4	80	20	22.9	0.8	slight collapse	111-112
5	75	25	22.9	0.8	slight collapse	111-112
6	70	30	22.7	0.8	good	109-110

- 5 -percentages of LDPE and LLDPE are expressed as weight percentages of the total polyolefine blend  
 -LDPE;mfi:2.0 g/10 min and density of 924 kg/m<sup>3</sup>  
 -LLDPE;mfi:2.8 g/10 min and density of 919 kg/m<sup>3</sup>  
 -blowing agent :isobutane

- 10 In this experiment a 150mm twin screw extruder was used for producing a 0.8mm sheet of foam from an LDPE and LLDPE blend. Again, run 1 was used as a control run with 100% LDPE. Runs 2 to 6 show the effects of steadily increasing the percentage of LLDPE. In this run, when the LLDPE was increased to 15% (run 3) through to 25% (run 5) the melt temperature became higher and foam quality degraded. Before run 6 changes in process conditions were made which brought the melt temperature down and consequently the foam quality was again fully comparable to the control value. As with Example 1, it was necessary to adjust the process conditions to control the melt temperature.

- 20 With the addition of 30% LLDPE it can be noted that a foam quality and density was achieved which is fully comparable to the 100% LDPE formulation.

**Example 4**

Run No.	LDPE Wt %	LLDPE Wt %	Foam density kg/m <sup>3</sup>	thickness mm	Foam quality	Melt. Temp. °C
1	100	0	17.4	3.0	good	107
2	90	10	17.6	3.0	good	107-108
3	85	15	17.4	3.0	good	108
4	80	20	17.4	3.1	good	109
5	75	25	17.4	3.1	good	109
6	65	35	17.2	3.1	good	109
7	55	45	17.4	3.0	fair	110-111
8	45	55	17.0	3.2	good	108-109

- 5 -percentages of LDPE and LLDPE are expressed as weight percentages of the total polyolefine blend  
 -LDPE;mfi:2.0 g/10 min and density of 923 kg/m<sup>3</sup>  
 -LLDPE;mfi:2.8 g/10 min and density of 919 kg/m<sup>3</sup>  
 -blowing agent :isobutane

- 10 The data shown in this table are the results from a further experiment using a twin screw extruder having a 150mm diameter. In this example an extruder was used to produce a 3mm sheet of foam from a blend of LDPE and LLDPE. As can be seen from the table, the melt temperatures for the LDPE/LLDPE blends in runs 2-6 were only slightly higher than the melt
- 15 temperature for the controlled run, No. 1. Thus, there was no need to change the process conditions and the foam quality remained good, no collapse or significant density increase was observed. In the 7<sup>th</sup> run the temperature was raised by 4°C and the foam quality degraded. The process conditions, specifically the temperature on the output of the extruder, were altered and, in
- 20 the 8<sup>th</sup> run the melt temperature remained fairly low and the foam quality was again fully comparable to that of the controlled run, the foam density actually being lower.

In all of these runs, by adding LLDPE to LDPE, and where appropriate, by controlling the melt temperature, a foam quality and density was achieved which is fully comparable or even better, than that achievable using 100% LDPE.

5        When it is appropriate to control the process conditions there are many parameters which can be altered. In these runs the output temperature of the extruder was set by adjusting the amount of water flowing to the heat exchanger on the output. Another way of doing this is to adjust the temperature set point of the electrical heating element on the output. It is also possible to  
10       control the shear heat generated by the mechanical action of the extruder, for example by adjusting the throughput, and other methods of controlling the melt temperature will readily occur to the skilled person.

Surprisingly, no significant increase in weight was found in these experiments for foams derived from a blend of LDPE and LLDPE, even at low  
15       levels of LLDPE. In fact, it was found to be possible to extrude foams containing up to 35% LLDPE on the single screw extruder, and foams containing up to 55% LLDPE on the twin screw extruder. Such foams would represent a significant cost saving compared to 100% LDPE foams, or foams produced using metallocene-catalysed LLDPE, or having cross linking agents  
20       added.

As an alternative to the use of LDPE, it is possible to use other polyolefins, such as polypropylene, particularly a high melt strength polypropylene. Non cross-linked resins, or resins with a relatively small amount of cross-linking, are particularly suitable.

25       In the present specification "comprises" means "includes or consists of" and "comprising" means "including or consisting of".

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process

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for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

## CLAIMS

1. A polyolefin foam comprising a plastics component and a blowing agent, the plastics component consisting primarily only of a first constituent and  
5 a second constituent; characterised in that the first constituent is a Ziegler-Natta catalysed linear low density polyolefin and the second constituent is a low density polyolefin.
2. A polyolefin foam according to Claim 1 in which the second constituent  
10 is a low density polyethylene.
3. A polyolefin foam comprising a plastics component and a blowing agent, the plastics component consisting primarily only of a first constituent and a second constituent; characterised in that the first constituent is a Ziegler-Natta  
15 catalysed linear low density polyethylene and the second constituent is a polypropylene.
4. A polyolefin foam according to Claim 3 in which the second constituent is a high melt strength polypropylene.  
20
5. A foam according to any preceding claim in which the plastics component consists primarily of from 1% to 85% of the first constituent, and from 99% to 15% of the second constituent.
- 25 6. A foam according to Claim 5 in which the plastics component consists primarily of from 5% to 10% of the first constituent, and from 95% to 90% of the second constituent.

7. A foam according to Claim 5 in which the plastics component consists primarily of from 10% to 15% of the first constituent, and from 90% to 85% of the second constituent.
- 5 8. A foam according to Claim 5 in which the plastics component consists primarily of from 15% to 20% of the first constituent, and from 85% to 80% of the second constituent.
9. A foam according to Claim 5 in which the plastics component consists  
10 primarily of from 20% to 25% of the first constituent, and from 80% to 75% of the second constituent.
10. A foam according to Claim 5 in which the plastics component consists  
15 primarily of from 25% to 30% of the first constituent, and from 75% to 70% of the second constituent.
11. A foam according to Claim 5 in which the plastics component consists primarily of from 30% to 35% of the first constituent, and from 70% to 65% of the second constituent.
- 20 12. A foam according to Claim 5 in which the plastics component consists primarily of from 35% to 40% of the first constituent, and from 65% to 60% of the second constituent.
- 25 13. A foam according to any preceding claim having a density of less than  $90 \text{ kg/m}^3$ , conveniently less than  $50 \text{ kg/m}^3$ , preferably less than  $30 \text{ kg/m}^3$ , most preferably less than  $20 \text{ kg/m}^3$ .

14. A foam according to any preceding claim in which the polyolefin foam is a closed cell foam.
15. A foam according any preceding claim wherein the density of the first constituent of 900 to 950 kg/m<sup>3</sup>, preferably between 917 and 930 kg/m<sup>3</sup>.
16. A foam according to any preceding claim wherein the crystallisation temperatures of the two constituents differ by more than 8°C.
17. A foam according to Claim 16 where the crystallisation temperatures differ by more than 10°C, preferably by about 12°C.
18. A foam according to any preceding claim wherein the melt flow index of the resin is less than 10, conveniently less than 5, preferably less than 3g/10 minutes.
19. A foam according to any preceding claim incorporating nucleating agents and ageing agents.
20. A method of manufacturing a polyolefin foam involving mixing as resin constituents primarily only a first constituent and a second constituent in an extruder adding a blowing agent to the resulting mixture, and extruding the resulting mix into foam form; characterised in that the first constituent is a Ziegler-Natta catalysed linear low density polyolefin and the second constituent is a low density polyolefin.
21. A method according to Claim 20 in which the second constituent is a low density polyethylene.



22. A method of manufacturing a polyolefin foam involving mixing as resin constituents primarily only a first constituent and a second constituent in an extruder, adding a blowing agent to the resulting mixture, and extruding the resultant mix into foam form: characterising in that the first constituent is a linear low density polyethylene and the second constituent is a polypropylene.

23. A method according to Claim 22 in which the second constituent is a high melt strength polypropylene.

24. A method according to any of Claims 20 to 23 in which the first constituent is present in an amount between 1% and 85% by weight of the total polyolefin content.

25. A method according to any one of Claims 20 to 23 in which the first constituent is present in an amount between 5% and 10% by weight of the total polyolefin content.

26. A method according to any one of Claims 20 to 23 in which the first constituent is present in an amount between 10% and 15% by weight of the total polyolefin content.

27. A method according to any one of Claims 20 to 23 in which the first constituent is present in an amount between 15% and 20% by weight of the total polyolefin content.

28. A method according to any one of Claims 20 to 23 in which the first constituent is present in an amount between 20% and 25% by weight of the total polyolefin content.

29. A method according to any one of Claims 20 to 23 in which the first constituent is present in an amount between 25% and 30% by weight of the total polyolefin content.
- 5 30. A method according to any one of Claims 20 to 23 in which the first constituent is present in an amount between 30% and 35% by weight of the total polyolefin content.
- 10 31. A method according to any one of Claims 20 to 23 in which the first constituent is present in an amount between 35% and 40% by weight of the total polyolefin content.
- 15 32. A method according to any of Claims 20 to 31 in which the foam is extruded to a density of less than  $90 \text{ kg/m}^3$ , conveniently less than  $50 \text{ kg/m}^3$ , preferably less than  $30 \text{ kg/m}^3$ , most preferably less than  $20 \text{ kg/m}^3$ .
- 20 33. A method according to any of Claims 20 to 32 in which the foam is a closed cell foam.
34. A method according to any one of Claims 20 to 33 wherein the density of the first constituent is between  $900$  and  $950 \text{ kg/m}^3$ , preferably between  $917$  and  $930 \text{ kg/m}^3$ .
- 25 35. A method according to any one of Claims 20 to 34 wherein the crystallisation temperatures of the two resinous constituents differ by more than  $8^\circ\text{C}$ , preferably by more than  $10^\circ\text{C}$ .

36. A method according to Claim 35 wherein the crystallisation temperatures differ by about 12°C.
37. A method according to any of Claims 20 to 36 wherein the first  
5 constituent has a melt flow index of less than 10g/10 minutes, conveniently less than 5g/10 minutes, preferably less than 3g/10 minutes.
38. A method according to any of Claims 20 to 37, involving the incorporation of nucleating agents and ageing agents.  
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39. A method according to any of Claims 20 to 38 involving the use of a twin screw extruder.
40. A method according to any of Claims 20 to 39 involving controlling the  
15 melt temperature of the mix.
41. A method according to Claim 40 involving matching the melt temperature of the mix to a pre-determined datum.
- 20 42. A method according to Claim 41 in which the datum is determined by extruding 100% of the second constituent.
43. A foam produced according to the method of any of Claims 20 to 42.
- 25 44. A polyolefin based foam substantially as herein before described with reference to the accompanying drawings.
45. A method of manufacturing polyolefin foam substantially as hereinbefore described, and as set out in the examples.

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46. Any novel feature or features described herein or illustrated in the accompanying drawings.



INVESTOR IN PEOPLE

Application No: GB 0228476.8  
Claims searched: 1-45 & 46 in part

Examiner: Dr Albert Mthupha  
Date of search: 30 May 2003

## Patents Act 1977 : Search Report under Section 17

### Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X	1-2, 5-12, 15, 18-21, 37-39, 43.	US 6114025 A	TENNECO, see column 1 lines 32-47, column 2 line 60-column 3 line 4, column 4 lines 15-24, lines 50-55, column 11 line 61-column 12 line 15, Claims 1, 4, 16, 22, 25.
X	1-2, 5-13, 15, 18, 20-21, 24-32, 34, 39-40, 43.	US 6096793 A	SEALED AIR CORP., see column 2 line 41-column 3 line 1, lines 10-22, lines 30-34, Example 1.
X	1-2, 5-13, 15, 18, 20-21, 24-31, 32, 34, 37, 39-40, 43.	US 4738810 A	DOW CHEMICAL, see Examples.
X	1-2, 5-13, 15, 18, 20-21, 24-31, 32, 34, 37, 39-40, 43.	WO 86/00628 A1	DOW CHEMICAL, see Examples.
X	1-2, 20-21.	<u>Foams 2000, International Conference on Thermoplastic Foam, 2<sup>nd</sup>, Parsippany, NJ, USA, Oct. 24-25, 2000 (2000), Nguyen L. et. al., pages 108-116, see Abstract.</u>	
X	1, 3-12, 22-31, 43.	WPI Abstract AN 1992-126239 [30] & JP 4059840 A (TONEN), see Abstract.	
X	1-2, 16-17, 20-21, 35-36, 39-41, 43.	WPI Abstract AN 1989-321381 [34] & JP 1240540 A (JSP CORP.), see Abstract.	

### Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.



INVESTOR IN PEOPLE

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**Field of Search:**

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC<sup>v</sup>:

C3C

Worldwide search of patent documents classified in the following areas of the IPC<sup>7</sup>:

B32B; B29C; B62D; B65D; B01J; C08F; C08J; C08L

The following online and other databases have been used in the preparation of this search report:

ONLINE : CAS ONLINE, EPODOC, JAPIO, WPI.